U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF CHEMISTRY AND SOILS
IN COOPERATION WITH IOWA AGRICULTURAL EXPERIMENT STATION

SOIL SURVEY OF PLYMOUTH COUNTY IOWA

BY

D. S. GRAY, IOWA AGRICULTURAL EXPERIMENT STATION, IN CHARGE, AND A. L. GRAY, U. S. DEPARTMENT OF AGRICULTURE

[Advance Sheets—Field Operations of the Bureau of Soils, 1923]

UNITED STATES
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[PUBLIC RESOLUTION—No. 9]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-Sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture"

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils]

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SOIL SURVEY OF PLYMOUTH COUNTY, IOWA

By D. S. GRAY, Iowa Agricultural Experiment Station, in Charge, and A. L. GRAY, U. S. Department of Agriculture

COUNTY SURVEYED

Plymouth County is in the northwestern part of Iowa. There are two counties between it and the Minnesota State line, and it is bordered on the west by the Big Sioux River, the boundary line between Iowa and South Dakota; on the north by Sioux County; on the east by Cherokee County; and on the south by Woodbury County. The county extends 24 miles from north to south and ranges from 33 to 40 miles east and west. It contains 24 civil townships and has a total area of 860 square miles, or 550,400 acres.

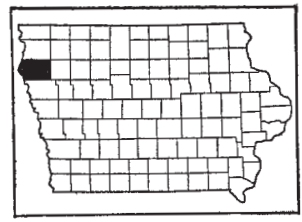


FIG. 28.—Sketch map showing the location of Plymouth County, Iowa

Plymouth County slopes toward the south and west in the general direction of the larger streams. The upland has an average elevation of 1,400 feet above sea level, but the streams have carved deep valleys from 100 to 300 feet deep, so that the surface features of the upland in every part of the county are determined by the character of the erosion and the extent to which the comparatively soft superficial deposits have been attacked and removed by streams.

Two distinct types of upland relief, representing different stages of erosion, may be recognized. One of these, prevalent over the entire county, except in the extreme southwestern part, has the characteristics of a gently eroded plain. Here the hills have smooth, rounded surfaces with intervening wide shallow valleys whose drainage channels reach all parts of the upland surface, leaving no flat undrained plain remnants or depressions. Erosion has been so gentle, however, that the thin loess covering has been cut through in very few places. The valleys are well developed, the slopes long and gentle, and the bottoms comparatively wide. The smooth surface is broken by steeper slopes in a few places, the result of recent rapid erosion. Such areas occur along Broken Kettle Creek and Bull Run in Westfield and Johnson Townships, south of Indian Creek in northwestern Preston Township, for several miles west of the bottoms along Floyd River in southern Washington Township, and along the larger streams in eastern Hungerford, Lincoln, and Elkhorn Townships. The bottom lands along West Fork Little Sioux River, south of Kingsley, and the lower part of Whiskey and Mud Creeks are bordered by rougher and steeper land than are those along the other stream courses in the county, and the valleys are from 90 to 170 feet below the surrounding hills.

The second type of upland relief is in the southwestern part of the county, mainly southwest of a line between Westfield and James, and including the greater part of Sioux and Hancock Townships and some of Perry Township. The relief in this area is the result of vigorous erosion upon soft, easily cut loess beds. The relief ranges from strongly rolling to hilly, the valley slopes are steep, and in many places rise as abrupt bluffs 150 or 250 feet above the adjoining bottom lands. The region is one of sharp hills and ridges with intervening valleys. Along Big Sioux River the hills rise from the bottom lands in steep slopes or bluffs, but the surface gradually becomes smoother a few miles back from the river and merges into the low relief of the upland.

Terrace or second-bottom lands are developed along all the larger streams of the county, but most extensively along the Floyd Rivers, Big Sioux River, and West Fork Little Sioux River. These terrace lands occur in areas ranging in extent from 40 to 500 acres, and vary in width from one-fourth to one-half mile. First-bottom lands occur along all the larger streams of the county, and narrow strips extend for several miles along the smaller drainage ways.

The first white settlers came to Plymouth County about 1856, at which time two settlements were made, one on Big Sioux River and the other on Floyd River. Plymouth County was organized from a part of Woodbury County in 1858, and the first county seat was established at Melbourne, a town not now in existence. When the Iowa Falls & Sioux City Railway, now a part of the Illinois Central system, reached Le Mars in 1869 the county seat was moved to that place. The advent of the railway provided a means of transporting farm products to outside markets and was a great stimulus to agricultural development.

The 1920 census gives the population of the county as 23,584, with 80 per cent, all except the residents of Le Mars, classed as rural. The rural population of the county has an average density of 22.1 persons to the square mile, rather evenly distributed. In 1910, 18.6 per cent of the population of the county was foreign born, but in 1920 this figure was reduced to 12.7 per cent.

Le Mars, the county seat, with a reported population of 4,683, is located a little north and east of the center of the county, on Floyd River. It is a manufacturing center and the seat of a denominational school, Western Union College. Akron with a population of 1,324, Remsen with 1,144, Kingsley with 1,072 and Merrill with 633, are the next largest towns.

Plymouth County is well supplied with railroad facilities. A good system of graded roads exists, but none have hard surfaces except for a few miles between Merrill and Hinton. These roads are excellent when dry and dragged, but are "heavy" during rainy periods. The roads follow land lines except where topographic features necessitate changes, as in the southwestern part of the county where the roads follow ridge tops and stream valleys to a large extent. Graded schools are maintained in some districts, and high schools in the larger towns.

CLIMATE

The climate of Plymouth County, typical of that of the midwestern Corn Belt, is characterized by severe winters and hot summers. The

data in the following table, covering temperature and precipitation, are from the United States Weather Bureau station at Le Mars, near the center of the county. According to these records the mean annual precipitation is 28.53 inches. The driest year on record was 1879 with a recorded rainfall of 16.49 inches, and the precipitation for the wettest year, 1884, was 41.70 inches. Almost two-thirds of the annual rainfall comes within the growing season, from May to September, and is favorably distributed, so that droughts are uncommon and dry weather usually prevails at harvest time. May and June are generally the wettest months and January and February the driest. The average annual snowfall is 24.4 inches. Blizzards, as well as occasional thaws, sometimes occur during winter.

The mean annual temperature is 46.1° F. January and February are the coldest months with mean temperatures of 16.2° and 18.3°, respectively, and July is the hottest month with a mean temperature of 72.7°. The lowest recorded temperature at Le Mars is −37°, and the highest is 105°. Freezing temperatures have occurred in each month except in June, July, and August. The average date of the last killing frost in the spring is May 4, and the first in the fall is October 2, allowing an average frost-free season of 150 days. Killing frost has been recorded as late in the season as May 31, and as early as September 12. The average frost-free season of 150 days is sufficient for maturing the staple grain and forage crops. The long, cold winters make it necessary to house the livestock and also limit the variety of fruits that can be grown profitably. Northwest winds prevail from November through April and south and southeast winds during the remainder of the year.

Normal monthly, seasonal, and annual temperature and precipitation at Le Mars

[Elevation, 1,224 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1879)	Total amount for the wettest year (1884)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	22.5	60	−33	0.93	0.43	2.60	4.8
January	16.2	58	−37	.55	.30	.10	4.3
February	18.3	62	−35	.77	.33	1.30	6.9
Winter	19.0	62	−37	2.25	1.06	4.00	16.0
March	32.1	84	−15	1.21	.39	2.60	4.0
April	47.4	94	11	2.87	.49	5.40	1.6
May	59.9	92	17	4.50	3.41	2.40	Trace.
Spring	46.5	94	−15	8.58	4.29	10.40	5.6
June	68.1	97	34	4.36	5.85	1.70	0
July	72.7	105	41	4.01	.12	8.90	0
August	70.8	99	35	2.79	2.28	4.60	0
Summer	70.5	105	34	11.16	8.25	15.20	0
September	62.4	97	22	3.25	.61	7.80	0
October	49.3	88	6	2.22	1.34	4.30	.5
November	33.1	75	−9	1.07	.94	.00	2.3
Fall	48.3	97	−9	6.54	2.89	12.10	2.8
Year	46.1	105	−37	28.53	16.49	41.70	24.4

AGRICULTURE

Agriculture has been the principal industry of Plymouth County since its earliest settlement. The early pioneers grew crops only for their own use, and hunting and trapping supplemented agricultural activities and provided a source of revenue. Prior to the coming of the railroads the growth of population was slow; agriculture was confined to the growing of corn, wheat, and oats, and cattle raising was engaged in to a small extent because of the abundance of good natural pasturage. In the sixties, after the construction of railroads which provided means of transporting produce to market, agricultural development progressed rapidly, and the passage of the homestead act was a great stimulus to immigration.

Wheat was most extensively grown during the early agricultural period, but after 1870 it was outranked by corn, which has been the most important crop ever since. The following table, compiled from the reports of the Federal census, shows the acreage and production of the leading crops and indicates the trend of agriculture in Plymouth County in the last 40 years:

Acreage and production of principal crops in 1879, 1889, 1899, 1909, and 1919

Crop	1879		1889		1899	
	Area	Production	Area	Production	Area	Production
	Acres	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Corn	41,310	968,032	124,417	4,785,679	158,241	5,998,020
Wheat	37,195	67,268	46,661	749,462	127,517	1,557,770
Oats	11,035	52,483	57,028	1,766,523	50,203	1,480,040
Barley	2,737	10,305	19,311	458,756	8,580	235,600
Rye	290	1,772	237	4,723	219	3,050
Buckwheat	190	1,467	159	1,287	57	370
Flax		8,536	4,940	50,394	716	6,810
Potatoes		39,748	2,414	258,640	2,336	252,908
		Tons		*Tons*		*Tons*
Hay (all kinds)	22,603	41,752	59,055	77,224		
Tame hay					23,396	40,475
Wild hay					27,516	38,403
Coarse forage					783	2,489

Crop	1909		1919	
	Area	Production	Area	Production
	Acres	*Bushels*	*Acres*	*Bushels*
Corn	176,804	7,204,988	174,648	7,595,853
Wheat	32,026	392,484	48,455	403,283
Oats	86,585	2,418,703	87,054	2,827,594
Barley	18,005	328,239	2,627	66,944
Rye	89	1,010	119	2,074
Buckwheat	88	1,662		
Flax	30	50	19	125
Potatoes	2,341	215,368	1,433	76,072
		Tons		*Tons*
Tame hay	40,301	68,259	40,488	80,153
Wild hay	23,935	36,278	16,200	23,225
Coarse forage	676	2,222	1,214	3,907

At present the agriculture of Plymouth County consists of raising for sale the crops common to the Corn Belt, of breeding and feeding hogs and beef cattle for home use and for market, and of dairy

farming. The leading crops, named in order of their importance, are corn, oats, hay, wheat, and barley. Orchard and small fruits, potatoes, and various garden crops also are grown.

Corn is the principal cash crop, and is practically all grown from locally produced seed. The most popular varieties are Reid Yellow Dent, Wimples Yellow Dent, Silver King, and Iowa Silvermine. Some Iowa Goldmine and considerable corn of an unknown variety also is grown. Seed is selected by many farmers before harvesting the crop, though considerable is selected at harvesting time and from the crib in the spring. One-half or more of the corn crop is fed to livestock on the farms; and the remainder is sold for local consumption or to elevators in near-by towns where it is shipped to terminal markets. Corn is generally check-planted, but on sod ground or where it is grown for silage it is drilled in.

Oats are grown on every farm and constitute the crop second in importance. The early varieties are grown chiefly, including Albion (Iowa No. 103), Kherson, Iowar, and Richland (Iowa No. 105). The Big Four, a midseason white oat, is grown to some extent. A large portion of the oat crop is grown as feed for work animals, or as a nurse crop for clover and alfalfa, and the remainder is sold. Hay, third in importance, is mostly fed on the farms, some is sold locally, but none is shipped out of the county. Wild or prairie hay is cut from bottom lands which are subject to overflow, and from depressed or rough broken upland areas.

Acreages of the various legume crops in the county in 1923 were as follows: Alfalfa, 13,621 acres; red clover and clover and timothy mixed, 13,150 acres; sweet clover, 3,675 acres; soy beans, 2,500 acres[1]; and miscellaneous legumes including white clover, alsike clover, and others, 4,212 acres.

Barley is grown as a cash crop and may replace oats in crop rotations, or be used as hog feed. Decreased yields and winter killing are given as the causes for the smaller acreage of wheat. Winter wheat is chiefly of the Turkey variety, and the popular spring wheats are Marquis, Bluestem, and Velvet Chaff. Potatoes are grown for home needs on every farm, though the demand requires that a large quantity be shipped in from outside the county. All farms raise sufficient garden truck for home use but no development of this industry has been made on a commercial scale. A few orchard and small fruits are grown on nearly every farm, and some farms produce apples for market.

The value of the various crops in Plymouth County in 1919 as given by the census are as follows: Cereal crops, $13,292,725; other grains and seeds, $18,569; hay and forage crops, $2,350,156; vegetables, $381,263; and fruits and nuts, $30,349. Although the crops grown represent the greatest source of agricultural wealth, this phase of farming is so closely allied to livestock raising that the two are hardly separable.

Probably the most extensive livestock industry in the county is hog raising. The total number of hogs on farms July 1, 1921, was 191,908,[2] and the number to the farm ranged from 50 to 150. The principal markets are Sioux City, where the hogs are marketed

[1] Estimated.

[2] Iowa Yearbook of Agriculture, 1921.

directly from the farm by truck, Chicago, Omaha, Minneapolis, and St. Paul. At present Sioux City is recognized as the largest truck-hog market in the world. Sows are bred for both spring and fall farrowing, the popular breeds being Poland-China, Duroc-Jersey, Spotted Poland-China, and Chester White, with some Hampshire and a good many grade hogs.

The feeding and breeding of beef cattle is an important industry, and there are a great many purebred herds in the county, including Shorthorn, Hereford, and Angus cattle, and many herds of grade animals. The greater part of the livestock fed out is native bred, although a number of carloads of western feeder livestock, bought on Sioux City, Omaha, and Kansas City markets, are fed. Finished beef cattle are marketed at Sioux City and Chicago. Although Sioux City is close at hand, large numbers of the better finished cattle are shipped to Chicago, and a few feeders of select cattle ship to eastern markets. There were 53,095 feeder cattle in the county on January 1, 1922, and the estimated value of all animals sold or slaughtered in 1919 was $5,408,041.

A number of farmers raise and feed sheep, but the practice is not so common as the raising of hogs and cattle. A few flocks of breeding sheep are kept, but greater activity is directed toward the fattening of lambs shipped in. The leading breed is the Shropshire. The number of sheep listed January 1, 1922, was 5,335, and the wool clip for 1919 was valued at $10,603. This is marketed partly through the Iowa Fleece Wool Growers' Association.

Dairying is very important in Plymouth County, and on January 1, 1922, there were 14,030 milk cows and heifers in the county. The total milk production for 1921 was 5,064,965 gallons, and the total revenue from dairy products in 1919 was $478,785. Dairying is carried on the year around. During the growing season the cattle are kept on pasture and given supplementary feed; and for winter feeding silage is utilized by many farmers. As many as 30 milk cows are kept on a farm. There are a number of purebred herds in the county, including Holsteins, milking Shorthorns, a few Jerseys, Guernseys, and a number of grade animals, and interest in purebred animals is rapidly increasing. The milk produced is marketed largely as cream, being separated on the farms and delivered to cream stations in the nearest towns, where it is shipped to Sioux City. Two cow-testing associations are in operation in the county, one in the Floyd River Valley and one in the Broken Kettle Creek Valley.

Horses are raised and used on all farms, but only a few professional horse breeders live in the county. Percheron and Belgian are popular breeds. Horses in the county numbered 18,465, and mules 803, according to the census figures for 1921. Poultry is raised on all farms and provides a dependable source of considerable income. Poultry and eggs in 1919 were valued at $714,984. The census figures for 1921 give the number of fowls in the county as 341,502, with an egg yield of 1,146,424 dozen eggs. Predominant breeds are Barred and Buff Plymouth Rock, White and Buff Wyandotte, Rhode Island Red, and White Leghorn.

Livestock is marketed by the farmers themselves, largely by truck to Sioux City. Grain crops are marketed through some so-called "cooperative" old-line elevators, and considerable corn goes to a

corn-products mill at Le Mars. This was formerly a large flour-producing mill, but with the great decrease in wheat production it was converted to the production of corn products. A livestock breeders' association and a sales pavilion company were organized in 1919, the latter maintaining a sales barn and pavilion at Le Mars.

The various types of soil in the county do not have a great effect on the kind of farming practiced, but do affect the management on individual farms. Marshall silt loam and Clarion silt loam are recognized as the soils of greatest productivity and desirability for general farm crops. The rougher areas of Marshall silt loam, shallow phase, and Knox silt loam are recognized as best suited for pasture of either native grasses or sweet clover, and the poorer-drained bottom lands are known to be poorly adapted to the production of the common field crops.

Various forms of crop rotation are practiced by the farmers of the county. The one commonly recognized as the most practicable consists of corn, oats, and clover and timothy. Some farmers modify this rotation, extending it two years by leaving the hay crop in that much longer or by substituting alfalfa for the clover and timothy. On the other hand, a large percentage of tenant farmers in the county do not seed to grass at all, or at the most only on a very small acreage of the farm, cropping continuously with corn and small grains. Low yields resulting from this practice, however, have led many farmers to follow a systematic rotation which includes a leguminous crop.

Land for corn is generally plowed in the fall, except where corn is to be planted on clover sod, in which case the land is pastured in the fall and plowed the following spring. Corn is nearly always planted in checkrows 3½ feet apart, but a small acreage is drilled when the crop is to be used for silage, or when planted on virgin sod, and is cultivated from three to five times during the season. When corn is followed by small grain, the ground is double-disked the next spring and the small grain is then sown. Corn yields much higher when it follows clover in a rotation than when it is grown on land continuously cropped to corn and small grain. Most of the crop is hand-picked, although power corn pickers are coming into more common use. A small acreage of the crop is "hogged down" each year on a great many farms; and where the crop is utilized in this way or for silage, soy beans usually are sown with the corn.

Ordinarily wheat is not grown for two successive years on the same land, and is sown usually on ground which has been plowed. Oats is seeded on disked corn-stubble land and is the favorite nurse crop for alfalfa and clover. The clover affords some pasturage after the oat crop is cut, and the following year it yields two cuttings. Alfalfa is cut three times a season and the stand is maintained for about five years if it is not crowded out by bluegrass.

Barnyard manure is used when available, and commercial fertilizers to a small extent. In 1919, 28 farms reported an average expenditure of $316.32 per farm for fertilizer. Some ground limestone also is used.

Farm buildings are usually well constructed. Farms are leased on both the share and cash basis. Cash rent varies from $5 an acre for pasture land to $10 or possibly $12 for highly cultivable land in good

location. Share leases of one kind or another are common. Such leases usually provide that the renter and owner share the corn crop equally, that the owner receive two-fifths of the small-grain crop, and that the renter furnish the seed, machinery, and labor.

Farm labor is largely native, although considerable harvesting and corn-picking help is transient, and not always satisfactory. Monthly wages in 1923 ranged from $30 to $40 and sometimes as high as $50, and day help received from $2 to $4. In 1919, with 75 per cent of the farms in the county reporting, an average annual labor expenditure of $604.54 to the farm was estimated.

The 1920 census report gives the number of farms in the county as 2,699 with an average size of 191.3 acres, of which 91.3 per cent or 174.6 acres per farm was improved land. The value of all property per farm averaged $56,634. Farms range in size from 40 to 1,000 acres or more. Land values vary according to location, improvements, character of the soil, and state of cultivation. Improved farms comprising the better types of soil sell for as high as $300 an acre, but the price is usually $200 or $225 an acre. Some of the rougher upland areas and first-bottom lands range in price from $75 to $150 an acre. The poorer rough broken land and untillable bottom lands have very low cash value.

SOILS [3]

Plymouth County lies in the prairie region of the United States, where the climatic and topographic influences have favored a rich, heavy growth of prairie grasses. At the time of the first settlement by white men the only forested areas of the county occurred along the larger creeks and rivers and in some restricted upland areas in the rougher parts of the county. The soils of the county show those characteristics which indicate that they have developed under the influence of a prairie vegetation and a comparatively high rainfall. Their most striking characteristic is the dark color imparted to them by the large quantity of black organic matter which has accumulated in the surface layer. This organic matter, derived from the decayed tops and roots of the prairie grasses, consists of finely divided carbonaceous material mixed with the soil particles. The quantity of this organic matter and the depth to which it has affected the color and physical character of the soil in any given locality are partly dependent on drainage conditions. On creek and river bottoms, outwash plains, and in swales on the upland it may continue to a depth of 15 or 20 inches or even 3 feet, but on the well-drained sloping areas it reaches a depth of only 14 inches or less.

On the flatter areas, like the stream bottoms, the water table was formerly rather close to the surface, so that a plentiful supply of moisture was available. Consequently a large quantity of organic matter accumulated in the surface soil and the upper part of the subsoil, and practically no leaching and but little oxidation took place

[3] Plymouth County adjoins Sioux County on the north and Woodbury County on the south. In places the soil maps of these counties do not agree on the borders, as a result of changes in correlation due to a fuller knowledge of the soils of the State. The Sioux loam and Carrington loam of Sioux County are here classed with the O'Neill and Dickinson series, respectively. On account of their small extension into Plymouth County, the Carrington silt loam and the Lamoure clay of Woodbury County have been mapped with the corresponding types of the Clarion and Wabash series in this county.

in the lower part of the subsoil. This has resulted in the development of a deep black topsoil over a heavy gray or drab, mottled subsoil. Such features are characteristic of the Lamoure, Wabash, and Cass soils, which occur on the poorly drained bottoms and terraces of the county.

Better drainage conditions have prevailed where the land surface is more rolling and where there has been a vigorous movement of soil water. Consequently, more leaching and more thorough oxidation have taken place and dark topsoils, 10 or 12 inches deep, and buff or light-brown subsoils with little or no mottling have developed. The topsoils are not so deep as those of the bottom and terrace soils, nor is there so great a concentration of clay in the subsoils. Lime carbonate, which constitutes an important constituent of the parent material, has not been leached to a great depth, usually to a depth of less than 3 feet. This group is represented in Plymouth County by members of the Marshall and Clarion series.

Over a part of the county this process of leaching and oxidation has been in operation for a sufficient length of time to remove the carbonates from the soil for a depth of more than 3 feet. The soils have the same dark color in the surface soil and a brown or buff-colored subsoil like those described above. Included in this group are the Dickinson, O'Neill, and Waukesha soils, the latter two being alluvial in origin and occurring on terraces above overflow.

A group of soils, characterized by light-colored topsoils, occurs in the county. As a result of the roughness of the areas in which they occur, these soils have become light in color because the dark carbonaceous material, derived from the prairie grass, has been washed away by erosion. The character of the land allows very little percolation of rain water through the soil, so that the run-off is high. As a result, the dark material is present in the soil at the base of the slopes, or has been carried still farther away to the flood plains of near-by streams. Leaching and oxidation have not been sufficient to remove the carbonates, so that the soils are very rich in lime, having nodules of this material in both topsoil and subsoil. This group of soils in Plymouth County is represented by Knox silt loam.

The soils in each of the groups described above are grouped into series on the basis of differences in mode of occurrence, parent material, color, and structure. Each series comprises soil types which are differentiated on the basis of the texture of the material constituting the topsoil. The 10 series of soils in Plymouth County are represented by 14 types of soil.

The parent materials of the upland soils of this county are from two sources, loess and glacial drift. The region in which Plymouth County is located was once covered by a vast sheet of ice which carried on or in it a mass of unassorted silt, clay, sand, gravel, and rocks. Following the deposition of this material called glacial drift, the area was covered with a mantle of smooth silty material known as loess, which is of a uniform friable nature throughout its depth, and is free from all coarse material such as gravel and rocks. It is generally believed by geologists to have been deposited by winds coming from the great regions to the northwest. The depth of this loess deposit varies from a few inches to as much as 50 or 60 feet, but averages between 10 and 15 feet. Ninty-eight per cent of the upland soils of

the county have developed on this mantle of loess. Since its deposition, however, erosion has removed it along some of the streams of the county, and in such places the soils have developed from the glacial-drift material on which the loess was formerly deposited.

The materials of loessial and glacial deposition have been acted upon by the agencies of weathering, erosion, and plant growth to form the different upland soils as they occur at the present time. In this county there are three types of soil of loessial origin, and two of glacial origin. They owe their characteristics in part to the parent material from which they have developed, but more largely they are the result of the soil-forming forces which have acted in varying degrees of intensity.

The loess and drift materials, removed by erosion and redeposited by the action of water, have been acted upon by the same soil-forming agencies and have produced the alluvial soils of the county as they now occur on the flood plains and stream terraces. Since the terrace soils occur in a region where the upland soils have a high lime content, it is notable that they are not calcareous. The terraces occur from 5 to 15 feet above overflow. The most extensive areas of bottom-land soils are along Big Sioux and Floyd Rivers. Here the soils are predominantly of silty texture, although some heavier members also occur, and some are of a calcareous nature. The Judson soil mapped in this county has a somewhat colluvial nature, in that it occurs in narrow strips along the bases of the hills which border the bottom lands, or in depressions on the uplands.

Following are brief descriptions of the soils of Plymouth County, as standardized not only for the county, but for the general region in which they occur.

The Marshall soils have dark-brown or very dark brown, silty topsoils underlain by brown or buff subsoils which are friable but not porous, and contain a high percentage of lime. Areas of Marshall soils are gently rolling. Marshall silt loam, with a shallow phase, is mapped. The shallow phase is so called because of the shallower depth of the topsoil, owing partly to the more rolling surface of these areas.

The Knox soils have yellowish-brown or buff-colored topsoils and yellow subsoils of about the same texture as the surface soil. The subsoils, and in many places the topsoils, are calcareous. The Knox and Marshall soils have developed on loess deposits. Knox silt loam is mapped in this county.

The Clarion soils have dark-brown or black surface soils and brown or yellow subsoils of heavy silt loam or silty clay texture. They are derived from calcareous glacial drift, and the subsoils contain limerock flour and fragments of limerock. Clarion silt loam is mapped.

The Dickinson soils have dark-brown or very dark brown topsoils and light-textured sandy or gravelly subsoils. These soils are developed from glacial-drift material. Dickinson loam occurs in the county.

The Waukesha soils have very dark brown topsoils and yellowish-brown or yellow subsoils of heavy silt loam or silty clay loam texture. These soils are of alluvial origin. They occur on terraces above overflow and represent loess and glacial-drift materials which have

been assorted and redeposited by water. Waukesha silt loam is mapped.

The Judson soils have very dark brown or nearly black topsoils and lighter-brown subsoils at a depth of about 30 inches. They are of both alluvial and colluvial origin and they occur above overflow on terraces and on colluvial slopes at the foot of bluffs. Judson silt loam occurs in Plymouth County.

The O'Neill soils are characterized by dark-brown topsoils and brown or yellowish-brown sandy or gravelly subsoils. They are of alluvial origin and occur on terraces above overflow. O'Neill loam and O'Neill sandy loam are mapped in this county.

The Wabash soils have nearly black topsoils and dark-drab or gray, heavy-textured subsoils, in many places mottled with iron stains. The soils are alluvial and comprise first-bottom lands. Wabash silt loam, Wabash silty clay loam, and Wabash clay are mapped.

The Lamoure soils are similar to those of the Wabash series, except that they have calcareous subsoils. Their topsoils and subsoils have essentially the same colors, and they are likewise of alluvial origin and occur on first bottoms. Lamoure silt loam and Lamoure silty clay loam are mapped.

One member of the Cass series, Cass fine sandy loam, is mapped. This soil consists of dark-brown surface soil underlain by lighter-brown sandy subsoil.

In the following pages of this report the different soils of Plymouth County are described in detail and their relation to agriculture is discussed. The accompanying map shows their distribution and the following table gives the extent of each soil type mapped:

Acreage and proportionate extent of Plymouth County soils

Soil	Acres	Per cent	Soil	Acres	Per cent
Marshall silt loam	369,344	81.3	Wabash silt loam	46,784	8.5
Shallow phase	78,016		Wabash silty clay loam	4,480	.8
Knox silt loam	22,784	4.1	Wabash clay	832	.1
Clarion silt loam	4,096	.7	Lamoure silt loam	3,712	.6
Dickinson loam	384	.1	Lamoure silty clay loam	1,472	.2
Waukesha silt loam	11,968	2.2	Cass fine sandy loam	64	.1
Judson silt loam	6,016	1.1			
O'Neill sandy loam	192	.1	Total	550,400	
O'Neill loam	256	.1			

MARSHALL SILT LOAM

The surface soil of Marshall silt loam is dark grayish-brown or very dark grayish-brown, smooth, mellow silt loam 12 or 14 inches deep. The upper part of the subsoil, to a depth of about 22 inches, consists of brown silt loam or heavy silt loam material generally of compact nature but not impervious, which gives the soil good natural drainage yet enables it to retain moisture. The lower part of the subsoil, continuing to a depth of 3 or more feet, consists of yellowish-brown or yellow, heavy silt loam or silty clay loam material, lighter in texture and more friable than that of the upper subsoil. In a few places some gray mottling occurs in the lower subsoil, and numerous lime concretions also occur in places within the plow depth.

Minor variations from the typical soil occur within areas mapped as Marshall silt loam where the soil is slightly lighter in color and shallower owing to eroded ridges and hills. These bodies are of small extent, comprising 1 or 2 acres each, and are not large enough to be shown on the map. At the bases of slopes along swales the surface soil may be a little deeper than typical, and of a darker color.

Marshall silt loam is widely distributed over most of the county, the largest unbroken bodies occurring in the eastern and northern parts and for some distance north of Potosia in the southwestern part. Many sections of land comprise this type of soil, with the exception of an occasional ribbonlike area of bottom-land soil along the streams.

This soil occurs on the gently rolling uplands which constitute a large part of the county. Areas of this land are characterized by gently undulating swells and gradual slopes to drainage ways. These features afford good natural drainage. The subsoil is sufficiently porous to allow percolation, but not to the extent to cause excessive underdrainage. The soil is retentive of moisture, so that periods of dry weather do not affect crop yields appreciably. Artificial drainage is necessary only in the bottoms of swales. Erosion in the swales may be prevented by keeping the land in bluegrass.

Marshall silt loam is by far the most important type of soil in the county and is highly prized for farming, at least 90 per cent of it being under cultivation. It is a prairie soil and was not naturally forested, but wood lots and windbreaks have been established since the county was settled.

Corn, oats, hay, and wheat are the principal crops, and some barley and potatoes are grown. The feeding and raising of beef cattle, hogs, and dairy cattle, and dairying are the most important livestock industries; but there is less dairying, sheep feeding, and alfalfa growing on this soil than on its shallow phase. Alfalfa growing is increasing, and most farmers grow a small acreage. Yields range from 4 to 7 tons an acre.

The average yield of corn on Marshall silt loam is between 40 and 45 bushels an acre. This average is frequently exceeded, and on farms which follow a systematic rotation which includes a legume the yield ranges from 50 to 65 bushels an acre, though yields of 70 bushels and more have been reported. Oats yield from 35 to 38 bushels an acre on farms on which legumes are not regularly grown, but on farms on which legumes are grown at regular intervals the yields range from 45 to 60 bushels. Sweet clover yields from 2 to 3 tons, and clover and timothy from 1½ to 3 tons an acre. Spring wheat yields from 8 to 12 bushels an acre, and winter varieties from 15 to 25 or possibly 30 bushels.

On a large number of the farms on this soil soy beans are planted with some of the corn each year. This crop is utilized in "hogging down" or is used for silage. Soy beans are occasionally seeded alone for the production of forage for hogs. The soy-bean varieties commonly used are Manchu, Black Eyebrow, and Ito San.

Clover and timothy, alfalfa, or sweet clover are seeded with oats as a nurse crop. Fields are left in alfalfa for about five years, and by that time the crop usually has been crowded out by bluegrass.

Sweet clover lasts only until the end of the second year and red clover the same length of time, although where timothy is seeded with the clover the ground is sometimes left in that crop for another year.

Over one-half of the plowing is done during the fall season, and plowed land is thoroughly disked and harrowed before planting corn. On a high percentage of the farms which are operated by owners crop rotation is practiced, but on the tenant-operated farms, with few exceptions, corn and small grains are grown almost continuously, that is, not in any definite rotation. Since over 50 per cent of the farms of the county are operated by tenants, the lack of a good rotation of crops accounts in part, at least, for the low average yields of crops on such a naturally fertile soil as Marshall silt loam.

Marshall silt loam is naturally fertile and easily tilled. Commercial fertilizers are not in common use, but some farmers have used ground limestone where alfalfa is to be grown, and a few use phosphatic fertilizers, either in the form of raw rock or superphosphate (acid phosphate). Barnyard manure and green manure constitute the fertilizers in common use. When properly applied these aid in maintaining soil fertility so satisfactorily that their value is appreciated more each year. The average farm does not keep enough livestock to produce manure in sufficient quantities to cover the farm with a good application once in four years. This deficiency, however, can be somewhat overcome through the use of a part of the leguminous crop as green manure. Whenever possible the second growth of clover or last growth of alfalfa should be used as pasturage or plowed under.

The current value of this kind of land ranges from $150 to $300 an acre, depending on improvements, location, and state of cultivation. During the land boom of 1919 some farms comprising this soil are reported to have been sold for more than $400 an acre.

Marshall silt loam, shallow phase.—The topsoil of shallow Marshall silt loam is only 7 or 8 inches deep, and consists of dark grayish-brown or very dark grayish-brown, mellow silt loam which contains traces of very fine sand. The upper part of the subsoil, to a depth of 20 inches, consists of brownish-yellow, friable silt loam which contains a noticeable quantity of very fine sand. The lower part of the subsoil, to a depth of more than 36 inches, consists of yellow silt loam material which contains considerable very fine sand. The subsoil, and in many places the topsoil, are calcareous, and in a few places fine gray mottlings and iron stains occur in the lower subsoil.

Some variations, accountable for in the differences of the texture of the subsoil material and in the surface features, occur within areas of this soil. In the western third of the county, in areas adjacent to Knox silt loam, the subsoil has a higher content of very fine sand than elsewhere in the county. In some places it is composed almost entirely of very fine sand, although there is generally sufficient silt or clay present to give the subsoil "body" and moisture-holding capacity. In the small areas of this shallow soil in the eastern and northern parts of the county the subsoil resembles that

of typical Marshall silt loam. In all locations the subsoil of this shallow Marshall soil is calcareous and contains lime nodules which occur within plow depth in many places.

Marshall silt loam, shallow phase, is developed most extensively in the western and southwestern parts of the county, but small tracts occur elsewhere. A body of considerable size is west of West Fork Little Sioux River in the southeastern part of the county, and another west of Mud Creek. A more or less continuous area occurs west of the Floyd River bottoms from the southern county line north to Merrill, and follows the west side of West Fork Floyd River to its junction with Mink Creek. In small isolated bodies this soil occurs on hilltops and ridges, but in the western part of the county, where it occurs adjacent to Knox silt loam, it is developed on lower slopes below areas of Knox soils.

Although not so deep or so fertile a soil as typical Marshall silt loam, this land is, when carefully managed, very productive, and is important agriculturally because of its extent. Probably three-fourths of it is under cultivation, the remainder being in pasture or supporting a forest growth.

The crops of greatest importance on this soil are corn, oats, and tame hay (chiefly alfalfa, red and sweet clovers, and timothy). Crop yields are somewhat less than on typical Marshall silt loam. Under careful management, corn yields of 50 or 60 bushels an acre may be obtained. Dairying is more important on this soil than on typical Marshall silt loam, though other branches of farming and livestock raising are carried on to an extent similar to that on the typical soil. Most of this land which is classed as tillable is devoted to the production of alfalfa and clovers, and the rougher tracts are left in pasture or forest to prevent damage from erosion. Commercial fertilizers are not used extensively, barnyard manure and green manure constituting the chief fertilizing materials.

Farm land comprising this Marshall soil sells from $50 to $175 an acre.

Since this soil occurs in rougher areas than the typical soil and is more subject to erosion, it requires more careful treatment to maintain its fertility. Its potential producing power is high, and where properly managed it is a productive soil. Care should be exercised in the preparation of seed beds, and contour plowing can be practiced to good advantage on much of this land. The rougher bodies are not suitable for cultivation, but are best utilized as pasture and woodland. In cultivated fields surface runs should be left in sod to prevent erosion.

KNOX SILT LOAM

The surface soil of Knox silt loam is grayish-yellow or grayish-brown silt loam 6 or 7 inches deep, and the upper part of the subsoil, to a depth of 30 inches, is somewhat variable, but in general it consists of slightly brownish yellow silt loam which contains a high percentage of very fine sand. With increasing depth the subsoil becomes pale yellow or buff colored, and has a larger content of very fine sand, in some places becoming very fine sandy loam or loamy very fine sand in texture. Occasional faint mottlings of brown iron

stains are present below a depth of 30 inches, and the topsoil and subsoil are calcareous throughout, containing lime and lime nodules.

Virgin Knox silt loam generally has a thin surface layer of dark material underlain, first, by a pale-yellow subsurface layer and then by the subsoil. The subsoil of the small isolated bodies occurring northeast of Westfield and in the hills bordering the west side of Floyd River between Merrill and Hinton has a greater content of silt and less sand, resembling more closely that of Marshall silt loam. In extremely rough areas there is some modification of the surface soil in that the ridge tops in places are very high in fine sand, but the extent of this variation is very small and the soil within a short distance has its normal silt loam texture.

Areas of rock outcrop are included with Knox silt loam as mapped, and consist of narrow ribbonlike areas along some of the lower slopes to drainage ways, the most extensive of these being along the Big Sioux River bluffs. Here little or no soil material has accumulated because the slopes are so steep. Such exposures are indicated on the map by rock outcrop symbols.

Knox silt loam occurs chiefly in the southwestern part of the county where it borders Big Sioux River and its bottom lands, and extends into the upland for a distance ranging from 1 to 6 miles. Elsewhere in the county small, round, or elongated bodies occur on hilltops and ridges within larger areas of shallow Marshall silt loam, or in some places within mapped areas of typical Marshall silt loam.

Areas of Knox silt loam are characterized by steep and broken slopes. In southern Westfield, Sioux, and Hancock Townships this land is extremely rough, and is dissected by numerous small drainage ways which are bordered by steep hills and narrow tortuous ridges. In this section of the county the surface is so steep that the soil material has slipped down and formed "catsteps" on the hillsides. As the region farther east from the river is approached the surface is somewhat less rough. Knox silt loam occurs exclusively on the upper areas and shallow Marshall silt loam occurs on the slopes which border the drainage ways. On the smooth parts of these slopes Judson silt loam occurs in many places. It is usually only these areas of Judson soil and shallow Marshall silt loam that are suitable for cultivation in southern Westfield, Sioux, and Hancock Townships, though some small irregularly shaped areas of Knox silt loam in this region are cultivated. Elsewhere in the county where Knox soil occurs in small tracts it is largely cultivated in conjunction with the adjoining soils.

Drainage on this land is good or excessive, but the subsoil is retentive of moisture and its capillarity is good. Where the surface drainage is excessive, crops suffer for want of moisture, but the soil is not extremely droughty.

Although this soil is rather extensive in the southwestern part of the county, it is of minor agricultural importance. It requires skillful management for profitable farming, but fair yields of crops may be obtained on the more desirable areas. Much of it is so unsuited to cultivation that it should be allowed to remain in pasture and woodland. This soil is not naturally a forested type and the sparse tree growth it supports is confined to the lower slopes, the hilltops being covered with wild grasses.

The same crops are grown on Knox silt loam as on Marshall soils, but with a greater proportion of sweet clover and alfalfa for the cultivable areas. The feeding of livestock is an important industry on this soil which is so well suited for use as pasture land. Crop yields are lower than on Marshall silt loam. Corn yields from 20 to 30 bushels an acre; oats, 20 bushels; alfalfa, 3½ to 5 tons; and sweet clover, 2½ to 3½ tons. Yields on land which has been well manured are higher, corn yielding from 40 to 50 bushels to the acre and oats about 40 bushels.

Considerable land of this type in the southwestern part of the county is owned by absentee landlords and rented. Improvements are not generally good and most tenants crop continuously with corn and oats. Owner-operated and some tenanted farms, however, are seeded frequently to alfalfa and sweet clover. On such farms a crop rotation of corn, oats, and clover or of corn, oats, and alfalfa is used. Where alfalfa is used it is allowed to stand for two or three years and in some cases longer.

Fertilizers consist chiefly of barnyard manure, which gives good results when used frequently in sufficiently large quantities, and green manures. Commercial fertilizers are not in common use.

Land values are extremely variable. Uncultivable areas have a negligible value from an agriculturist's viewpoint, but can not be bought for less than $15 an acre. The more desirable and tillable tracts have an approximate value of from $50 to $100 an acre, depending on location and improvements. Many smaller bodies are sold in conjunction with Marshall silt loam and its shallow phase. In such places Knox silt loam reduces the value of the farm as a whole.

Means of improving this soil consist in the liberal use of barnyard manure and in proper rotation of crops. Rough areas which are subject to erosion when the virgin sod is disturbed by plowing should be left in grass.

CLARION SILT LOAM

The surface soil of Clarion silt loam is very dark grayish-brown mellow silt loam about 12 inches deep. This is underlain, to a depth of 24 inches, by brown or yellowish-brown calcareous, heavy loam or silty clay loam material which contains some gritty material and a few rocks or pebbles. The lower part of the subsoil, to a depth of 3 feet or more, is brownish-yellow or yellow silty clay or clay, containing sand or other gritty material and a few rocks. It also is calcareous, effervescing with acid and containing limestone flour and fragments of limestone. Iron stains are numerous in the lower part of the subsoil.

The composition of Clarion silt loam varies but slightly in different parts of the county although locally it approaches to some extent the character of the type of soil which joins it. Where it adjoins shallow Marshall silt loam and Knox silt loam, the surface soil is somewhat shallower than where this type adjoins typical Marshall silt loam. Adjacent to typical Marshall silt loam the surface soil of Clarion silt loam, to a depth of 2 feet or more, shows evidence of having developed on loessial deposits which overlie glacial drift. The body occurring in sections 3 and 10 of Portland Township does not have the highly calcareous subsoil, but is typical in other respects.

Areas of Clarion silt loam are usually gently rolling, and natural drainage is good but seldom excessive.

This is a fertile and productive soil and is usually included in farms comprising other types of soil. On account of its position along the lower slopes, it is usually used as pasture land. Crop yields on the better areas like those adjacent to Marshall silt loam are practically the same as on the Marshall soil. This soil is cultivated in the same manner as the adjoining soils and receives no special treatment. Methods of improvement suggested for Marshall silt loam apply to this soil.

DICKINSON LOAM

The surface soil of Dickinson loam is dark grayish-brown or very dark grayish-brown loam, about 12 inches deep, and is underlain to a depth of 24 inches by brown, heavy loam or silt loam material which contains considerable sand. The subsoil is brownish-yellow or yellow loamy sand which becomes more definitely sandy with increasing depth.

Dickinson loam occurs in two areas of about 300 acres, comprising parts of sections 3, 4, 9, and 10 of Portland Township,[4] and in another area in the northeastern part of Garfield Township. These developments comprise the total extent of this type of soil in Plymouth County. These areas are undulating or gently rolling, and natural drainage is good or excessive.

About three-fourths of this soil is under cultivation, the remainder being utilized as pasture land. Crops common to this region, including corn, oats, clover, and alfalfa are grown. Corn yields less than on Marshall silt loam because the open subsoil does not hold moisture well.

Dickinson loam is generally handled in the same manner as the adjoining type of soil. Special attention should be directed toward increasing and maintaining its organic matter through liberal applications of manure and systematic seeding to leguminous crops.

WAUKESHA SILT LOAM

Waukesha silt loam has a topsoil of dark grayish-brown or very dark grayish-brown smooth silt loam about 12 inches deep. The upper part of the subsoil is light brown or medium brown heavy, silt loam material about 24 inches deep, and the lower part is brownish-yellow or yellow, heavy silt loam or silty clay loam material.

Only slight variations in this soil occur in Plymouth County. The body in the northeast quarter of section 24 in southern Sioux Township (T. 91 N., R. 49 W.) differs somewhat from the typical soil in that the subsoil is calcareous, effervescing freely with acid.

Waukesha silt loam occurs along the larger streams throughout the county, chiefly along Floyd and West Floyd Rivers, Indian, Mink, Deep, and Clear Creeks, and West Fork Little Sioux River. Its occurrence along Big Sioux River is confined to a few small bodies. It is an alluvial terrace soil composed largely of sediments washed from the Marshall soils on the hill lands and redeposited along the streams where it occurs on benchlike formations, from 5 to 15 feet

[4] This body joins with Carrington loam in Sioux County. Soils such as these were mapped with the Carrington soils at the time Sioux County was surveyed.

above overflow. Waukesha silt loam resembles Marshall silt loam closely in depth and color of soil layers and in crop adaptations. This soil has, however, a lower content of lime than Marshall silt loam, and except in a tract in southern Sioux Township, it does not effervesce with acid.

Areas of Waukesha silt loam are flat or sloping, and drainage is good, though not excessive. This soil is important agriculturally and is practically all under cultivation. Corn, oats, and hay are the principal crops, and yields are about the same as on Marshall silt loam. General livestock farming, including the production of beef cattle, dairy cattle, and hogs, is practiced. On very few farms is the land entirely of this soil, so that it is generally farmed in connection with adjoining types, being handled and fertilized in the same manner as Marshall silt loam.

JUDSON SILT LOAM

Judson silt loam has a very dark grayish-brown or nearly black silt loam topsoil 18 inches deep, underlain by medium dark-brown, mellow silt loam material which changes at a depth of 30 inches to brown silt loam texture. In places the dark color continues to a depth of 3 feet or more, with but slight difference in the texture of the material. This variation has developed west and southwest of Akron, just east of Big Sioux River.

Judson silt loam occurs on terraces along Big Sioux River, as gently sloping areas of land at the base of hills adjoining bottom lands, at the foot of slopes along intermittent drainage ways in upland areas, and in other parts of the county. The land is gently sloping or flat, and drainage is good except on the flatter areas.

This soil is productive, but is of minor importance agriculturally because of its small extent. Some of it is under cultivation, the smaller bodies being farmed in conjunction with adjoining soils. The crops common to the region are grown, including corn, hay, oats, and other small grains. Where the soil is well drained yields are generally as large or larger than on Marshall silt loam. Barnyard manure and green manure are used.

The value of land where this kind of soil predominates depends largely on its location with respect to other soil types. It may range in price from $75 to as high as $175 an acre.

The principal need of this soil is better drainage either by means of tile or open ditches.

O'NEILL SANDY LOAM

O'Neill sandy loam has a dark-brown or dark grayish-brown sandy loam surface soil, averaging 10 inches in depth, and a brown or yellowish-brown subsoil which, to a depth of 24 inches, consists of sandy loam material or loamy sand, and becomes more sandy with increasing depth. This, in turn, is underlain by yellowish-brown or yellow sand, and in places the subsoil is a stratified mixture of gravel and sand.

This type of soil is not of great agricultural importance in Plymouth County. It occurs as small isolated bodies along Big Sioux River and Deep Creek. Drainage is generally excessive, and only a small acreage is under cultivation.

O'Neill sandy loam is the principal source of gravel in the gravel pits at Akron, as here the subsoil is chiefly gravel, whereas in other places it is composed mainly of sand. On account of its limited occurrence in small areas, this soil forms but a small part of individual farms.

O'NEILL LOAM

The surface soil of O'Neill loam is dark grayish-brown or very dark grayish-brown friable loam about 15 inches deep, and below this the upper part of the subsoil is sandy loam material which, as it approaches a depth of 25 inches, has a high content of sand and is of lighter color. The lower part of the subsoil, at a depth of 28 inches or more, is brown or yellowish loamy sand or sand.

O'Neill loam is inextensive in Plymouth County, its occurrence being limited to one body of about 256 acres in section 4 of Portland Township.

This land is flat or sloping, and natural drainage is good or excessive, owing to the porous nature of the subsoil. Some of this land is under cultivation, and yields are fair under favorable conditions; but periods of prolonged dry weather decrease them considerably.

O'Neill loam requires careful management to be made productive. The organic matter and humus of the soil can best be maintained through the liberal application of barnyard manure and plowing under green manures and cornstalks.

WABASH SILT LOAM

The surface soil of Wabash silt loam is very dark grayish-brown or nearly black silt loam about 15 inches deep, underlain to a depth of 24 inches by heavy silty clay loam material of dark-drab or gray color. The lower part of the subsoil is generally silty clay, mottled with gray, brown, and drab, and stained with iron. In some areas the soil below the surface layer shows a gradation in color from nearly black to gray or drab, and the material becomes heavier with depth. In some places in small stream bottoms, the soil is dark colored throughout the entire 3-foot section, the chief difference between the various layers being an increase in clay with depth. The surface soil has a comparatively high content of organic matter.

Wabash silt loam is widely distributed throughout the county and is the most extensive bottom-land soil. It comprises the bottom land of most of the small streams and a large proportion of that along the larger streams, where it ranges in width from one-twelfth mile to 1 mile or more. Along Big Sioux River, except above Akron, this soil occurs intermingled with other soils, though elsewhere, and particularly along parts of Floyd River, it is developed in more continuous bodies.

Areas of the land are flat or gently sloping. Old stream valleys which are more or less filled in afford the only relief. Drainage is generally poor, and most areas of this soil along the smaller streams are partially inundated during high water or after very heavy rains. The surface ranges from 2 to 6 feet above the normal water level of the streams and is practically all subject to occasional overflow. Natural drainage on some of the higher-lying areas where inundation

is less frequent is fair, but the low-lying areas are dependent on artificial drainage to render them suitable for farming.

Probably 30 per cent of the Wabash silt loam is cultivated, the remainder being in native grasses and forest. The principal cultivated crops are corn and wheat, though some of the land is devoted to clover and alfalfa. Much of this land is used as pasture land for cattle and hogs, and a scattered forest growth is present on areas bordering stream courses along old stream channels.

The soil is productive and high yields are obtained under favorable drainage conditions. Corn yields from 40 to 70 bushels an acre; spring wheat, from 10 to 15 bushels; fall rye, from 25 to 35 bushels; clover and timothy, from 2 to 3 tons; and alfalfa, from 4 to 6 tons. These yields are exceeded under exceptionally favorable conditions on well-drained areas; but on poorly drained tracts or those which are subject to overflow and occassionally require replanting of crops, yields are considerably lower, and sometimes crops fail.

Wabash silt loam is not difficult to manage when well drained. Much of this land which is tillable is cropped continuously to corn and wheat; and although yields are maintained fairly well under this practice, the use of a legume at regular intervals would increase the productiveness. Continuous cropping also impairs the physical condition of the soil, making it more difficult to cultivate on account of puddling and clodding. Rotation of crops and occasional applications of manure would prove very beneficial.

Areas of this soil which do not possess good natural drainage and on which artificial drainage is not practicable, are best suited for pasturage or wild hay, as they support a luxuriant growth of wild grasses. The construction of dikes along Big Sioux River has reclaimed extensive tracts of Wabash silt loam and of other kinds of bottom-land soils for the production of cultivated crops.

Land comprising Wabash silt loam with good improvements sells for $125 to $200 an acre. Areas not suitable for cultivation and without improvements have a much lower value.

WABASH SILTY CLAY LOAM

The surface soil of Wabash silty clay loam, to a depth of about 14 inches, may be very dark brown, dark grayish-brown, or nearly black silty clay loam. The upper part of the subsoil, to a depth of 24 inches, consists of dark-gray or drab material of clay loam or silty clay texture, with faint iron stains, slightly mottled in places, and underlain by lighter-colored clay, which is stained with iron and is slightly mottled with gray or drab.

This soil occurs most extensively along Big Sioux River. A few fairly large bodies are along Floyd River, and a few others in the valleys of other streams. Its occurrence is confined to the first bottoms of streams, usually in conjunction with Wabash silt loam. The surface is flat or depressed and natural drainage is usually deficient.

Wabash silty clay loam is of less agricultural importance than Wabash silt loam, being of smaller extent and less productive. Because it is heavier in texture, it is more difficut to work and to keep in good physical condition; but it is a fertile soil and produces excellent crops under favorable conditions. Natural drainage is usually poor and ditches and dikes are necessary to keep out flood water.

The same crops are grown on this soil as on Wabash silt loam. In some localities crop yields may be less, but they frequently are about the same. The use of barnyard manure and green manures will aid greatly in making the soil more friable, easier to plow, and less apt to bake and crack. On land devoted to cultivable crops, extreme care should be exercised to keep down weeds and to maintain a surface mulch.

Wabash silty clay loam is usually of less value than Wabash silt loam on account of its heavier texture. In general, the means of improvement and the values given for Wabash silt loam apply equally well to Wabash silty clay loam.

WABASH CLAY

Wabash clay consists of very dark gray, grayish-brown, or black clay underlain to a depth of about 20 inches by gray and drab mottled clay stained with iron. The upper part of the subsoil is darker in color than the lower part which is a mottled gray, yellow, and brown, heavy tenacious clay stained with iron.

This type of soil occurs in the county only along the southern part of Big Sioux River. Some of it is under cultivation and the remainder is grassland.

The common crops are corn, wheat, and hay. The soil can be easily handled only under a very narrow range of moisture conditions. Its heavy character is an important factor in its management. The plowing under of barnyard manure and green manure will assist in rendering the soil more friable. Better drainage would prove beneficial.

LAMOURE SILT LOAM

The surface soil of Lamoure silt loam is very dark brown or black, silt loam 14 inches deep, underlain to a depth of 24 inches by a dark-gray or drab clay loam or silty clay. The lower part of the subsoil is gray or drab, mottled silty clay or clay which is highly calcareous.

This soil is one of the less extensive first-bottom soils of the county. It occurs in narrow areas along the headwaters of various drainage ways, and to a small extent constitutes the bottom land along some of the larger streams. It has the same origin and characteristics of occurrence as Wabash silt loam, and is of like productiveness and value, differing only in its greater lime content. It is much less extensive than Wabash silt loam and therefore of less agricultural importance.

LAMOURE SILTY CLAY LOAM

The topsoil of Lamoure silty clay loam to a depth of 15 inches is very dark brown or nearly black silty clay loam, comparatively high in organic matter. The subsoil to a depth of 24 inches is dark-gray or drab, heavy silty clay loam material or silty clay stained with iron and highly calcareous.

This soil comprises first-bottom lands which are subject to overflow at times of high water. It is inextensive, and occurs exclusively along the lower courses of Big Sioux and Floyd Rivers.

Lamoure silty clay loam differs from Wabash silty clay loam in that the subsoil, and in places the surface soil, contains sufficient

lime to effervesce with acid. The same methods of handling the soil are practiced, and crop yields and land values are practically the same.

CASS FINE SANDY LOAM

The surface soil of Cass fine sandy loam consists of dark grayish-brown fine sandy loam about 15 inches deep. The upper part of the subsoil to a depth of 28 inches is brown loamy sand or light sandy loam, the sand content increasing with depth. The lower part of the subsoil is brown loamy sand which grades into pure sand at a depth of about 30 inches.

This soil is unimportant agriculturally, one body in section 17 of Portland Township being its only occurrence in Plymouth County. This land is along the river bank, has irregular surface, and supports a sparse tree growth. Cass fine sandy loam in Plymouth County is noncultivable and is of little value except as pasture or forest land.

SUMMARY

Plymouth County is located in extreme western Iowa and comprises 860 square miles, or 550,400 acres.

The county is part of a broad plain which is gently rolling, though the southwestern part of the county is rougher. Drainage is effected through Big Sioux and Floyd Rivers and their tributaries, and is well established. Elevations in the county range from 1,075 to 1,450 feet above sea level.

Plymouth County was first settled about 1856, and development was rapid after the advent of the railroads. The county has a population of 23,584, of which 4,683 are classed as urban. Much of the population is of German descent.

The principal towns are Le Mars, Akron, Remsen, Merrill, and Kingsley, and the county is well supplied with railroads, good dirt roads, schools, and telephone lines.

The mean annual precipitation is 28.53 inches, distributed favorably for the growth of crops common to the Corn Belt. The mean annual temperature is 46.1° F., and the frost-free period averages 150 days.

Agriculture is well developed in the county and includes the production of the various grain and hay crops, livestock raising, and dairy farming. The principal cereal crops are corn, oats, and wheat, and the chief hay crops are clover and timothy, alfalfa, and sweet clover. Raising and fattening hogs is the principal livestock industry, and the raising of beef cattle, dairy cattle, and sheep is second in importance. A large proportion of the farmers follow a system of crop rotation which includes a legume.

The total number of farms in the county in 1920 was 2,699, with an average size of 191.3 acres. Of these farms, 42.4 per cent were operated by owners, 57.1 per cent by tenants, and 0.5 per cent by managers. Farms are usually leased on the share basis, although some farms rent for cash.

Local communities supply sufficient labor except at harvest time, when extra help is obtained from near-by cities. Wages usually range from $30 to $40 a month, or from $2 to $4 a day. Land values over most of the county range from $100 to $250 an acre, but in the

poorer sections from $40 to $100 an acre. In general, farm improvements are good.

Ten series of soils represented by 14 types of soil were mapped in the county. According to the source of the materials from which they have developed, the soils may be grouped into four classes—loessial, glacial, terrace, and first-bottom soils.

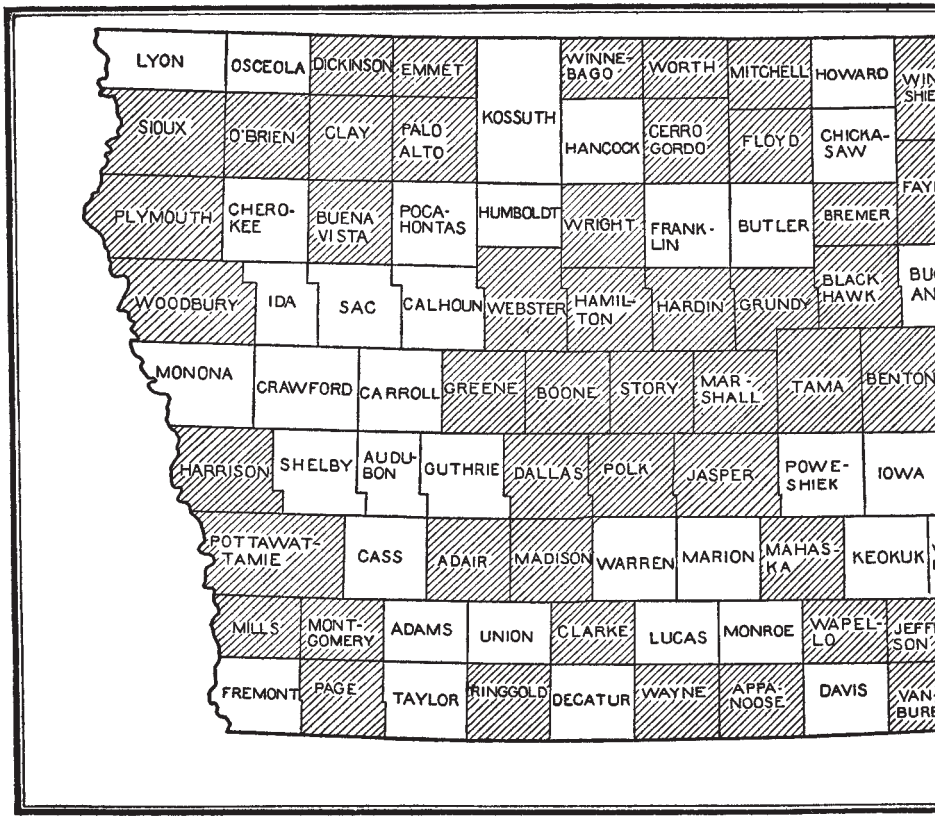
The loessial group includes the Knox and Marshall soils. Marshall soils are dark colored, fertile, and are highly prized for general farming. The areas of shallow Marshall silt loam are more rolling than the typical Marshall soil. Knox silt loam is a light-colored soil comprising rough land, much of which is unsuited for cultivation.

The glacial soils are represented by Clarion silt loam and Dickinson loam. Clarion silt loam is a dark-colored, productive soil developed on the lower slopes throughout the county. Dickinson loam, occurring only in the northwestern part of the county, has a dark topsoil underlain by sand, and is less desirable than Marshall silt loam.

The terrace or second-bottom soils of the county include the Waukesha, O'Neill, and Judson soils. Waukesha silt loam is a dark-colored soil, productive, and is highly prized. Judson silt loam is likewise a dark-colored and fertile soil, but poor drainage in places detracts from its value. The O'Neill soils yield well under favorable conditions, but they are underlain by sand, and hence suffer for lack of moisture during dry periods.

The first-bottom soils of the county include the Wabash, Lamoure, and Cass soils. The first two are similar, being dark colored and fertile, but differ in that the Lamoure soils are calcareous. Cass soils are underlain by sand, and are less desirable than the members of the Wabash and Lamoure series. Lack of good natural drainage and the fact that these soils are subject to inundation at times of high water are the chief factors limiting production on these first-bottom soils.

○



Areas surveyed in Iowa, shown by shading

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U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
C. A. BROWNE, ACTING CHIEF
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP
PLYMOUTH COUNTY
IOWA

IOWA AGRICULTURAL EXPERIMENT STATION
C. F. CURTISS, DIRECTOR
W. H. STEVENSON, IN CHARGE SOIL SURVEY
P. E. BROWN, ASSOCIATE IN CHARGE

R. 49 W.
R. 48 W.
R. 47 W.
R. 46 W.
R. 45 W.
R. 44 W.
R. 43 W.
T. 93 N.
T. 92 N.
T. 91 N.
T. 90 N.
SIOUX CO.
PLYMOUTH CO.
BOUNDARY LINE
WOODBURY CO.
CHEROKEE CO.
PRESTON
GRANT
ELGIN
MEADOW
PORTLAND
FREDONIA
WESTFIELD
JOHNSON
WASHINGTON
AMERICA
MARION
REMSEN
STANTON
SIOUX
LIBERTY
PLYMOUTH
UNION
HENRY
HUNGERFORD
LINCOLN
ELKHORN
GARFIELD
PERRY
HANCOCK
Akron
Le Mars
Remsen
LEGEND
Cass fine sandy loam Cf
Marshall silt loam Ms
Clarion silt loam Cs
Ms Shallow phase
Dickinson loam Dl
O'Neill sandy loam Os
Judson silt loam Js
O'Neill loam Ol
Knox silt loam K
Wabash silt loam Ws
Lamoure silt loam Ls
Wabash silty clay loam Wl
Lamoure silty clay loam Lc
Wabash clay Wc
Waukesha silt loam W
CONVENTIONAL SIGNS

Thomas D. Rice, Inspector, District 3.
Soils surveyed by D. S. Gray, of the Iowa Agricultural Experiment Station, in charge, and A. L. Gray of the U. S. Department of Agriculture.

Scale 1 inch-1 mile

Field Operations
Bureau of Soils
1923